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Strategic and Operational Considerations for the Implementation of Performance Based Logistics (PBL) Within the Japan Maritime Self Defense Force

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June 2010

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The Japan Maritime Self Defense Force (JMSDF) will initiate its first performance-based logistics (PBL) contract in fiscal year 2010. This first contract is an experiment in contracting with private firms to provide direct support for military forces. Performance-based logistics is a very new concept for the Japan Self Defense Force, and many policy issues remain unaddressed. The purpose of this Master's project is to explore the critical strategic and operational risks and benefits that the JMSDF should consider concerning outsourcing public functions. This project identifies aspects of the experiences of the United States with performance-based logistics and how the JMSDF might learn from these experiences in order to emulate successes where conditions allow and avoid critical mistakes and failures.

This study analyzes publicly available literature and documentation on performance-based logistics contracting, as well as contractor logistics support contracting, to develop a summary of the U.S. experience with PBL. We analyzed 37 articles to summarize their findings and claims with regard to cost, performance, performance measurement, risk, information systems, appropriateness of a particular weapon system for PBL implementation, and organizational capability to evaluate, implement and manage a PBL contract.

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STRATEGIC AND OPERATIONAL CONSIDERATIONS FOR THE IMPLEMENTATION OF PERFORMANCE BASED LOGISTICS (PBL) WITHIN THE JAPAN MARITIME SELF DEFENSE FORCE

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
ASD	Air Supply Depot
BCA	Business Case Analyses
BR	Break Rates
CLS	Contractor Logistics Support
DoD	Department of Defense
GAO	General Accounting Office
IUID	Item Unique Identification
JMSDF	Japan Maritime Self Defense Force
MFHBR	Mean Fright Hours Between Removals
MFHBUR	Mean Flight Hours Between Unscheduled Removals
MMC	Maritime Material Command
MoD	Japan Ministry of Defense
MTBF	Mean Time Between Failures
PBL	Performance Based Logistics
RFID	Radio Frequency Identification
SSD	Ship Supply Depot

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Gaku Harada

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I. PREFACE

The Japan Maritime Self Defense Force (JMSDF) [1] will initiate its first performance-based logistics (PBL) contract in fiscal year 2010. This first contract is an experiment in contracting with private firms to provide direct support for military forces. Performance-based logistics is a very new concept for the Japan Self Defense Force, and many policy issues remain unaddressed. The purpose of this Master's project is to explore the critical strategic and operational risks and benefits that the JMSDF should consider concerning outsourcing public functions.

A. INTRODUCTION

Many domestic laws, regulations and rules affect PBL in Japan. It is difficult for the Japan Ministry of Defense (MoD) to change national laws, because those laws cover entire ministries and offices. Although some laws contain exceptions for the military—such as the Civil Aeronautics Law, the Law for Controlling the Possession of Firearms or Swords and Other Such Weapons, and the Fire and Disaster Management Law—acquisition- and contract-related laws have no exceptions for the military. National laws should be thought of as immutable regulations governing the establishment, funding and management of PBL contracts. On the other hand, regulations and rules created by the MoD can be amended, and we may assume that such regulations and rules will be changed so that PBL contracts may be used. In this project, we will treat national laws as constraints on PBL contract design, implementation and management, while rules and regulations established by the MoD will be considered flexible with respect to implementing PBL.

B. BACKGROUND

A general understanding of the laws, regulations and rules that apply to military contracts in general, and performance-based contracts in particular, is necessary at the outset of any discussion of public contracting. We will first discuss how a PBL contract

[1] JMSDF: Japan Maritime Self Defense Force (JMSDF) is the national naval military service of Japan.

works and some of the legal issues surrounding such a contract, and then discuss why the JMSDF wants to implement such contracts. Finally, we will introduce the supply and contract organizations in the JMSDF, and discuss their role in creating and governing such contracts.

1. Definition of Performance-Based Logistics (PBL)

A PBL contract is an outcome-based performance approach to contracting for logistics support of weapon systems that has become increasingly popular within the defense sector of both the United Kingdom and United States. Traditionally, both the public and private sectors have established contracts for specific equipment, parts, and labor and then managed these inputs to achieve a specific management target. Performance-based logistics contracts differ from this approach, in that they purchase a performance outcome such as an availability rate, an on-time delivery or fill rate, or a reliability rate such as mean time between failure (MTBF) or mean flight hours between unscheduled removals (MFHBUR), based upon an assumed or forecasted operating tempo and set of operating conditions. The theory behind the performance-based logistics contract is that by purchasing an outcome both customers and suppliers share risk. For example, in a traditional contracting arrangement, customers might contract for the purchase of spare parts and keep inventory so that they have enough on-hand to achieve a stated performance goal and achieve their missions. However, in a PBL contract, the supplier provides *an outcome* and therefore takes on a portion of the risk associated with the contract in the form of inventory, which they would ideally own.[2]

Performance-based logistics is about not only risk sharing, but also cost reduction and higher performance. One of the biggest reasons why the JMSDF wants to implement PBL is to reduce cost. Although there is a popular claim that PBL contracts compress costs, evidence to the contrary exists. For example, the General Accounting Office (GAO) points out that the evidence of cost reductions by PBL contracts within the Department of Defense (DoD) is not clear (GAO, 2008). With respect to performance, many analyses show how PBL improves outcomes. For example, the U.S. Department of

[2] If the supplier does not own the inventory, then the incentive to improve reliability is reduced.

Defense Inspector General found improvements in availability, reliability, training opportunity, and Navy depot workload and product for the SH-60 helicopter (DoD Inspector General, 2006).[3] However, the public literature contains no conclusive evidence that demonstrates an increase in performance coincident with a reduction in costs. In other words, some studies and documents claim reductions in cost and others claim improvements in performance but little evidence supports a cost for performance measure that conclusively demonstrates an improvement in performance while reducing costs.

2. Mechanism of PBL

The key features of a PBL contract are cost reduction and performance improvement, which are achieved through a carefully selected set of performance targets and metrics, mechanisms to measure performance, and appropriate incentives or disincentives associated with each performance target. Normally, higher cost and higher performance are positively correlated; in other words, the more you pay, the better performance you have, but the less you pay, the worse performance you have. However, the idea behind PBL is that you may achieve both cost reduction and performance improvement; the contract customers control the incentives of their suppliers while enjoying the seemingly contradictory benefits of performance improvement.

There are many means of providing incentives to suppliers; one of the most popular is performance-based compensation. Under performance-based compensation, suppliers receive a bonus if they achieve a performance target. Another incentive is the long-term contract. Most contracts have a period of performance of less than one year (especially if the government is the customer) because, with some exceptions, the fiscal year is one year. As an example of one exception, DoD PBL contracts for H-60 helicopters have terms ranging from 31 months to 10 years (Inspector General, 2006).

[3] This report also stated that the selection of performance factors and measurement should be considered with more care.

Supplier disincentives in the contract may include a penalty (in the form of a fee or reduced customer payment) associated with a supplier's failure to meet a performance target.

3. PBL Implementation in JMSDF

a. Motivation for the Implementation of PBL in the JMSDF

Because of the recession, and the demands of taxpayers, the MoD plans to cut 15% of its acquisition costs through 2011. The JMSDF will try to achieve a 15% reduction in costs without having to reduce rates of operation and equipment utilization. The United States and Great Britain have been using the PBL concept, particularly for aviation assets, for several years. Aware of some of the success stories coming out of Great Britain and the U.S., the MoD established the "MoD Total Acquisition Reform Plan" in March 2008, which created laws and rules governing PBL for those contracts implemented after 2009. Shortly afterward, the Internal Bureau in MoD[4] decided to fund a "Study to Reduce Cost for Equipment" in 2011 to investigate the present condition of equipment, as well as its logistics support strategy, and identify how other countries are reducing their costs (to include the use of PBL) and apply those methods where it is feasible. The JMSDF will begin its PBL pilot model in 2010 and implement a "Study of Optimum Maintenance for Logistics Systems" in 2011.

b. PBL Pilot Model

The JMSDF is planning to implement its PBL pilot model by applying a performance-based contract to the management of about ten repair parts for the MCH-101 helicopter.[5] In this PBL pilot model, the JMSDF plans to achieve a certain inventory

[4] Internal Bureau in MoD is the organization that supports the Minister of Defense. Most of the members of Internal Bureau in MoD are civilian workers.

[5] The MCH-101 is a minesweeping, transportation, and anti-submarine patrol helicopter that is designed by EH Industries and produced by Agusta Westland in the United Kingdom. This helicopter is operated by five countries including Japan. Agusta Westland has a PBL contract with the Royal Navy and Royal Air Force as well as other nations (Agusta Westland, 2009).

level for the designated repair parts and have the contractor maintain that inventory; if inventory falls below the desired amount then the contractor will refill inventory within a specified time.

Figure 1. MCH-101 helicopter (From: Kawasaki Aerospace Company, 2010)

The JMSDF chose the MCH-101 for a PBL pilot model based upon the following criteria:

- the rate of operation of the MCH-101 is very low
- the lead time of some parts is very long[6]
- the proposed PBL contractor, Agusta Westland, produces the MCH-101 and has experience with the weapon system, and
- the PBL contract stakeholders are limited, because there are just two main suppliers, so it is easier for JMSDF to structure its organization around the PBL contract

The budget for the PBL pilot model has already been approved by the Diet. During the PBL pilot, the JMSDF has established several conditions:

[6] For example, the lead times of some parts are 20 months.

- the JMSDF will not provide performance-based compensation because it is difficult for the JMSDF to offer bonuses under current laws[7]
- suppliers will have a long-term contract as an incentive[8]
- should the number of aircraft increase, the JMSDF will offer repairable spare parts to the suppliers, and
- suppliers will provide all necessary data to evaluate their performance to the JMSDF, and the JMSDF will evaluate the pilot model using a third party

The JMSDF is conducting a cost-benefit analysis and contracting for the PBL pilot model using a third party contractor.

c. PBL Implementation Plan

The JMSDF plans to use its experience and lessons learned from the MCH-101 and expand the PBL concept to other equipment should the pilot be successful. Currently, the JMSDF imagines using PBL contracts for the entire maintenance level of training aircraft, and for higher levels of maintenance (i.e., above shop level)[9] of operating aircraft.

Figure 2 shows the PBL implementation plan provided by the Maritime Materiel Command (MMC). According to this information, while the JMSDF will continue the PBL pilot model until 2014, they will apply results of the MCH-101 pilot to the Study of Optimum Maintenance Logistics Systems in 2011. The Study of Optimum Maintenance Logistics Systems seeks to find the optimum maintenance and logistics practices (to include contracting maintenance out to private contractors) for all weapon systems and then coordinate contracts in 2012 for the P-1,[10] TH-135[11] and other platforms from 2013.

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[7] On the other hand, JMSDF will not establish a special penalty for failure to meet a performance target but instead claim a standard, normal penalty, which is 0.05 percent of the contract price per day if companies do not meet the established performance criteria.

[8] The long-term contract is desirable for the contractor because it allows them to make business expansion and long-term capital investment plans, as well as lock in contracts with their suppliers.

[9] Shop level maintenance is a kind of Inspection-level maintenance. In shop level maintenance, some assemblies or components are dismantled and inspected.

[10] The P-1 is a patrol aircraft of JMSDF, which is designed to replace P-3C patrol aircraft. The P-1 is manufactured by Kawasaki Heavy Industry and now it is under development.

[11] The TH-135 is an imported training helicopter of JMSDF. The TH-135 is manufactured by Eurocopter.

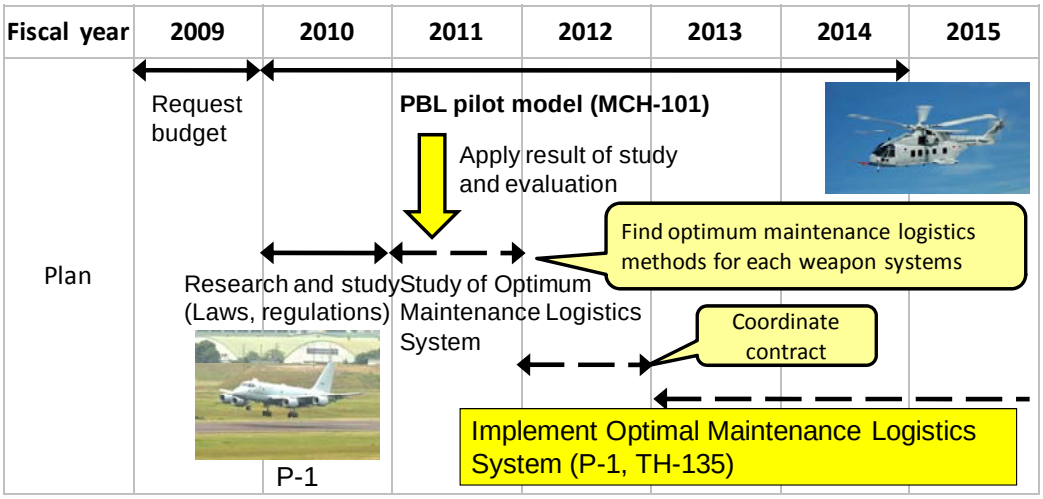

Figure 2. PBL Implementation Plan (From: MMC, 2009)

4. Key Laws Affecting PBL Use

The key laws affecting PBL for the JMSDF are the Public Accounting Law, Public-Finance Law and State-Owned Articles Management Law. These laws never anticipated PBL contracts or the outsourcing of public functions to the private sector and, therefore, any implementation of an outsourcing contract such as PBL will likely run afoul of one or more of these laws. In 2010, the MoD will conduct a study to determine the impact of these laws on PBL and PBL implementation and then determine whether PBL may be implemented under the current laws or whether the laws need to be amended to accommodate PBL.

a. Public-Finance Law

The Public-Finance Law was enacted on March 31, 1947. This national law is the fundamental law governing public finance in Japan and establishes the types of budget, budget compilation and execution of payments permissible by public institutions. According to article 14-2, the government can execute budget expenditure over continuing fiscal years if the contract(s) requires more than one year to complete. In article 14-3, the law mentions that the Diet can extend the execution to more than 5 years, though normally there is a 5-year maximum. The theory behind PBL is that, with long-term contracts, suppliers will be motivated to improve quality and lower their operating

costs, capturing the difference between the contract price and their reduced costs in the form of additional profit. However, until now, continuing expenditures beyond 1 year are used only for the construction of ships and submarines, so it is difficult to apply to PBL contracts. On the other hand, according to article 15, the government can use bond-related expenditures (with approval from the Diet) for long-term contracts, but there is no precedent within the MoD for such an action.

b. Public Accounting Law

The Public Accounting Law was enacted on March 31, 1947. This national law states the procedures related to revenue, expenditure and contracts. According to article 9-11, the contract officer has to verify the completion of a contract; however, there is no contract officer who has the experience to verify performance, and indeed the JMSDF as a whole does not know how to evaluate performance. According to article 29-6, contract officers must decide how to establish a target price to select contractors, but current guidance is insufficient for contract officers to establish an appropriate price for performance.

c. State-Owned Articles Management Law

The State-Owned Articles Management Law was enacted on May 22, 1956. This national law states the procedures to manage national assets. According to article 7, the Minister of Defense must manage MoD's property in-house, so he cannot outsource the management of parts or assemblies to the commercial companies. In the PBL pilot model, the JMSDF provides each part to the company, so it can clear this law; in the future, however, this law will become a big barrier against PBL contracts.

5. JMSDF Knowledge of PBL

The JMSDF's PBL knowledge is currently insufficient. Though there are many articles related to PBL in English, however these articles are invisible to anyone conducting a search in Japanese; furthermore, most Japanese cannot read well in English, so it is very difficult for Japanese military people to study about PBL by themselves. As a result, the JMSDF cannot help relying on third parties or private defense contractors.

The use of third-party private defense contractors offers the JMSDF a lot of beneficial information as a result of their long relationship and because they are experts in their weapon systems. However, the use of third parties presents some complications as well as it may be difficult for them to understand and fully integrate with all of the JMSDF's unique systems, processes and legal requirements. Moreover, some third parties are not reliable. For example, a 2006 Nimrod crash in Afghanistan was attributed by some experts to a lazy third party contractor that did not supervise the maintenance properly and the customer was completely reliant on that third party for all maintenance expertise (Chuter, 2009). Further, the private firm's fundamental goal and mission is to earn money whereas the fundamental goal and mission of the JMSDF is to defend the lives and property of the citizens of Japan and therefore there is a basic, structural conflict of interest between the two and the potential for bias that would favor the firm and compromise the JMSDF is real. In fact, the information presented by private defense contractors makes little mention of cost reduction, performance improvement or the potential risks associated with performance-based contracting (Saito, 2009; Eurocopter Japan, 2009).

6. Supply and Contract Flow of JMSDF

Figure 2 shows the supply and contract flow in the JMSDF. The Minister of Defense decides upon the overall goal, upon which the Chief of Staff, JMSDF, makes the general plan. The Maritime Material Command (MMC) procures, keeps and maintains materials that are used by the JMSDF and also conducts logistics research. The Ship Supply Depot (SSD) and Air Supply Depot (ASD) are managed by MMC. SSD performs acquisition, storage, supply and maintenance for ships while ASD performs the same activities for aircraft. Most contracts are made by SSD and ASD, and goods and services are sent from private defense contractors to squadrons via SSD or ASD. Ships and aircraft themselves are not procured through MMC, SSD or ASD but are acquired by the Equipment Procurement and Construction Office.

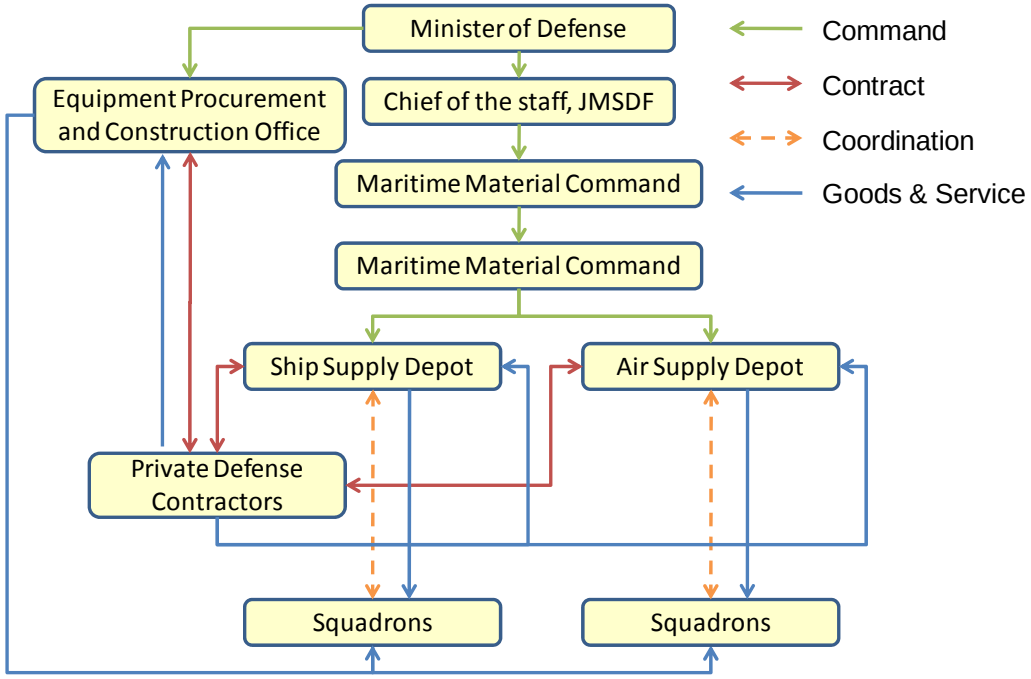

Figure 3. Supply and Contract Flow of JMSDF

C. PROBLEM STATEMENT

It is currently difficult for the JMSDF to gain objective information or knowledge about PBL, which means that they cannot objectively assess costs, appropriately measure performance, or mitigate the potential risks when considering the implementation of a PBL contract.

D. PURPOSE OF THE PROJECT

The purpose of this project is to identify aspects of the experiences of the United States with performance-based logistics and how the JMSDF might learn from these experiences in order to emulate successes where conditions allow and to avoid critical mistakes and failures.

E. RESEARCH QUESTIONS

There are seven research questions that define this project's purpose.

- How should JMSDF measure and evaluate the cost of a PBL contract?

- How should JMSDF measure and evaluate the performance of a PBL contract?
- How should JMSDF consider performance measurement?
- What are the primary and secondary risks associated with the PBL concept as it pertains to the JMSDF and what measures can be taken to mitigate them?
- What kind of information system(s) should JMSDF construct to manage PBL contracts?
- What kind of criteria should JMSDF consider when determining whether to use a PBL support strategy for a particular weapon system?
- How can JMSDF implement and evaluate PBL contracts after they are executed?

F. SIGNIFICANCE OF THE PROJECT

This project will help the JMSDF reduce risks associated with PBL contracts by highlighting the experiences of two countries that have been implementing PBL for several years. Additionally, this project will provide direct guidance and input to the JMSDF in their development of PBL policy. At present, only one military officer in the MMC is tasked to implement PBL contracts in JMSDF. The JMSDF needs input and recommendations on implementing PBL without relying solely on the materials and documents provided by private defense contractors.

G. METHODOLOGY

This study analyzes *publicly available* literature and documentation on performance-based logistics contracting, as well as contractor logistics support contracting, to develop a summary of the U.S. experience with PBL.

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II. ANALYSIS OF THE LITERATURE

We began by selecting 76 documents that included peer-reviewed research, Department of Defense guidance, and various public and private reports that directly addressed PBL, Contractor Logistics Support (CLS) or outsourcing. Of the original 76 documents, we chose 37 that described PBL implementation and outcomes based upon their research merit[12] (see Appendix A). We analyzed these 37 articles to summarize their findings and claims with regard to cost, performance, performance measurement, risk, information systems, appropriateness of a particular weapon system for PBL implementation, and organizational capability to evaluate, implement and manage a PBL contract.

A. COST

Eighteen articles directly addressed cost. The PBL literature contains not only claims of cost efficiency and reductions in total ownership cost, but also calls for more research and better data to assess whether, in fact, the theoretical claims made about PBL can be realized.

Many organizations expect to save total ownership costs by implementing PBL (Keating & Huff, 2005; Reeve, 2001). Cohen (2007) found that cost-sharing support and maintenance services can generate "up to seven times as much profit as do sales of original products over the lifetime of product use to the contractors." The Japan MoD and JMSDF also expect cost reduction and compression of the supply chain. Theoretically, outsourcing reduces costs, because many people think that the public sector is far more inefficient than the private sector (Sink, 1997). Further, officials inside the U.S. DoD claim they can reduce costs by implementing PBL (Ahern, 2004; Secretary of Defense, 2004). In a theoretical paper by Tallant, Martin, and Hedrick (2008) the authors claim that the cost efficiency of PBL contracts is high. Cost efficiency refers to the effectiveness of action or performance outcome relative to the absolute cost.

[12] The other 37 documents not included in the literature analysis were contractor-developed documents that were little more than corporate advertisements or broad, simplistic overviews of PBL as a concept.

Theoretically, an award for good performance gives the supplier an incentive to improve in cost and performance thereby increasing the cost efficiency of the contract. Cohen (2007) and Kim, Cohen and Netessine (2007) have shown, through principal-agent models, the increase in cost efficiency as a result of a performance award. However, Cohen (2007) also observed that, while it is fair to assume that one must invest money to make money, it is not clear how to determine the appropriate amount of payment and expected cost savings for a PBL contract.

In those rare cases where it is acknowledged that PBL may increase costs it is argued that it is a result of a premium for the additional risk contractors share as part of the contract (Nowicki, Verma & Parry, 2008). It is has also been suggested that highly reliable systems may have high performance contracting costs. Highly reliable equipment is often equipment that is also critical and its failure may not only represent a surprise event but also a time sensitive repair requirement for an organization. Because suppliers must be prepared to respond and repair the equipment quickly, there may be significant costs involved. On the other hand, highly reliable equipment may rarely break down and in a PBL contract this means the customer may feel as though they are paying without any services actually being rendered (Kim, Cohen, Netessine & Veeraraghavan, 2008).

Despite many claims that PBL can reduce costs, no documented evidence exists for such cost savings (GAO, 2008; GAO, 2008b; Inspector General, Department of Defense, 2004; Inspector General, Department of Defense, 2006; Landreth, Wilhelm & Corporon, 2005; Tallant, Martin & Hedrick, 2008). Not only is empirical evidence of cost savings through the use of PBL contracts lacking, there is no way to predict future cost reductions as a result of PBL implementation. While a performance award provides an incentive for suppliers to lower costs, there is very little systematic tracking of costs and performance. Individual military services have difficulty calculating total costs for their programs, particularly infrastructure support costs (Inspector General, Department of Defense, 2003). Additionally no statistical evidence supports a relationship between contract performance and the performance award (Kirk & DePalma, 2005). It is widely agreed, based upon empirical studies, that more cost data are needed, both in quantity

and quality, to evaluate cost appropriately and to price PBL correctly (Boito, Cook & Graser, 2009; Cohen & Nunes, 2008; Coryell, 2007; Department of the Navy, 2007; Inspector General, Department of Defense, 2003). The cost data required, for both PBL and non-PBL contracts, includes inventory and equipment costs as well as training costs, salaries and management fees, and facilities for both equipment and personnel.

B. PERFORMANCE

Ten articles directly address PBL performance. Performance improvement is one of the primary reasons the JMSDF would like to implement PBL. Ahern (2004) states that PBL can improve weapon system performance, however, this is simply a claim and very little empirical evidence backs the statement. The Inspector General, Department of Defense (2006) conducted an empirical investigation into H-60[13] helicopters and found that availability, reliability, training opportunities workload and product was improved by using PBL. The GAO has also found instances of PBL improving performance (GAO, December 2008). However, other studies have pointed out that PBL may not be achieving the goals of improving readiness for major weapon systems (Inspector General, Department of Defense, 2004). An empirical study of Auxiliary Power Units[14] found that reliability did not improve through the use of PBL (Landreth, Wilhelm & Corporon, 2005). Statistically, 52.1 percent of customers have noted a service-level improvement by outsourcing logistics functions, but 33.8 percent of customers felt that time and effort spent on logistics did not decrease (Sink & Langley, 1997).

The business case analysis (BCA) is the primary instrument for determining whether a performance-based logistics contract should be considered and it is also the document that must be reviewed to determine whether the contract is performing as expected. However, it is not clear what cost elements should be in a BCA (there is no standard); nor has there been clear guidance from the Department of Defense on how the BCA should be constructed. Individual services are creating their own guidance and

[13] H-60: H-60 is one of the most popular military helicopters in the world. U.S. Army, Navy, Air Force and JMSDF use this type of helicopter.

[14] Auxiliary Power Unit: Auxiliary Power Unit is a small engine on an airplane that supplies electric power and compressed air when the main engines are not working.

standards for BCAs. In those instances where there were BCAs conducted and a PBL contract was used, the BCA was not always updated, validated or verified.

The BCA is a set of methods to evaluate performance and help to make decisions in PBL implementation. The governmental organization must first define what should be included in a business case analysis and establish specific criteria and methods for evaluating PBL support. The BCA should be updated frequently during the lifecycle of the weapon system (GAO, December 2008; Ausink, Baldwin, Hunter & Shirley, 2002) and data should be collected in a standardized format (GAO, December 2008). The BCA should analyze PBL not only under peacetime operation but also under wartime operational scenarios and operating tempos, otherwise it will fail to capture the full costs of the contract should there be war (Coryell, 2007).

An analysis of the PBL literature shows that performance measures, as well as their implementation and use, are heterogeneous. In some cases of PBL implementation, performance has not been measured. Kirk and DePalma (2005) found performance measurement to be critical in order to implement an effective PBL contract. However, in many cases, the government finds it difficult to establish measurable performance standards (Ausink, Baldwin, Hunter & Shirly, 2002). And while Buyukgural (2009) and Sols, Nowicki and Verma (2008) have developed mathematic models to measure performance, Kirk and DePalma (2005) insist that empirical performance data are required to evaluate PBL contracts.

C. PERFORMANCE MEASUREMENT

Eighteen articles directly addressed performance measurement. The literature of military PBL implementations addressed performance metrics in the following way.

1. Variety of Performance Metrics

Performance metrics can be classified as effectiveness (which includes availability, readiness, reliability and customer feeling), efficiency and response time.

a. Effectiveness

Effectiveness describes how the goal is accomplished (Mentzer & Konrad, 1991). Effectiveness includes availability, readiness, reliability and customer feeling. Setting effectiveness goals is very important for PBL, because without them, we cannot assess the applicability of PBL (Sols, Nowicki & Verma, 2008). Because this study addresses aviation, these effectiveness metrics are described in aviation terms.

(1) Availability: Availability is "the percent of time that a system is available for a mission or the ability to sustain operations tempo" (Buyukgural, 2009). Some studies found that the "numerator of availability is not and should not be translatable to dollars" because, especially in the military, the mission is not monetary benefit (Doerr, Lewis & Eaton, 2005). Availability metrics include:

- *Partially mission-capable supply:* "The percentage of time an aircraft can fly at least one but not all of its missions for reasons attributed to supply" (Boito, Cook & Graser, 2009, p. 36)
- *Not mission-capable supply*: "The percentage of time an aircraft is grounded and cannot fly any of its missions for reasons attributed to supply" (Boito, Cook & Graser, 2009, p. 36)
- *Mission-incapable awaiting parts*: "The percentage of time that an aircraft is unable to perform its assigned mission because of a lack of parts" (Boito, Cook & Graser, 2009, p. 36)
- *Aircraft availability*: "Mission-capable hours divided by total possessed hours" (Boito, Cook & Graser, 2009, p. 38)
- *Mission-capable rate*: "The percentage of all possessed aircraft capable of fulfilling at least one of their assigned missions" (Boito, Cook & Graser, 2009, p. 38)
- *System availability and sub-system availability*: The rate that shows how many hours we could use particular system or sub-system per total ownership time (Kim, Cohen & Netessine, 2007)
- *Operational availability*: The rate that shows how many hours we could conduct operations per total operation demand (Nowicki, Verma & Parry, 2008)

(2) Readiness: Readiness is the rate of availability of parts or equipment. It is different from availability, because readiness does not always affect mission capability. Readiness measures include:

- Issue effectiveness: "The percentage of customer requests that have been filled by items in the inventory; includes the fulfillment of any request, not just requests for items the supply is authorized to stock" (Boito, Cook & Graser, 2009, p. 36)

- Stockage effectiveness: "The percentage of customer requests filled by items that the supply system is authorized to stock" (Boito, Cook & Graser, 2009, p. 36)

- On-time fill rates: The rate that customer could get some parts or equipment on time (Kirk & DePalma, 2005, p. 27)

(3) Reliability: "Reliability is the measure of a system in meeting mission success objectives" (Buyukgural, 2009)

- *Mean time between repairs*: "Flying hours divided by repair actions" (Boito, Cook & Graser, 2009, p. 36)
- *Mean time between failure (MTBF)*: "A basic measure of reliability for reparable items; the average amount of time that all parts of an item perform within their specified limits" (Boito, Cook & Graser, 2009, p. 36; Kirk & DePalma, 2005, p. 27)
- *Break rates (BR)*: "The number of breaks, defined as landings with write-ups requiring major maintenance that ground the aircraft, per sortie" (Boito, Cook & Graser, 2009, p. 37)
- *Mean Flight Hours Between Removals (MFHBR)*): The average number of flight hours before particular parts are removed. MFHBR includes regular maintenance and contingency maintenance (Kirk & DePalma, 2005, p. 27

- *Mean Flight Hours Between Unscheduled Removals (MFHBUR)*: The average number of flight hours before particular parts are removed. MFHBUR exclude regular maintenance (Kirk & Depalma, 2005, p. 27)
- *Mission reliability*: The rate that shows number of successful missions per total number of missions (Nowicki, Verma & Parry, 2008)
- *Mean down time*: Mean time during which particular system could not be used (Nowicki, Verma & Parry, 2008)

(4) Customer feelings: One of the metrics to measure availability, readiness and reliability is customer feelings. Customer feelings can be very important—if a squadron feels that the service provided is very convenient (or inconvenient) then this is useful feedback from a resource allocation and overall management standpoint.

However, customer feelings are often ignored, especially when the service is provided by the government, to the government. To measure human behavior is difficult, so we tend to skip these measurements (Mentzer & Konrad, 1991).

- *Customer satisfaction*: Customers feel satisfaction when their objective is fulfilled (Lambert & Burduroglu, 2000)
- *Customer-value added*: Customer-value added is "perceived value of company's offer" divided by "perceived value of competitive offers" (Lambert & Burduroglu, 2000)

b. Efficiency

Efficiency "is the measure of how well the resources expended are utilized" (Mentzer & Konrad, 1991). Efficiency metrics include:

(1) Cost per Unit Usage: "The total operating cost divided by the appropriate unit of measurement for a given system" (Buyukgral, 2009, p. 24)

(2) Logistics footprint: "The Government/contractor size or presence of deployed logistics support required to deploy, sustain and move a system. The measurable elements of logistics footprint include inventory/equipment, personnel, facilities, transportation assets and real estate" (Buyukgral, 2009, p. 24).

c. Response Time

Response time is the time needed to draw output from some input. Response time metrics identified in the literature include:

(1) Repair turnaround time: "A measure of the length of time to repair an item and return it to the stock system" (Boito, Cook & Graser, 2009, p. 36)

(2) Mean time to repair: "A basic measure of maintainability: the total maintenance time divided by total number of failures" (Boito, Cook & Graser, 2009, p. 37)

(3) Logistics response time: "The period of time from logistics demand signal sent to satisfaction of that logistics demand. 'Logistics demand' refers to systems, components, or resources (including labor) required for system logistics support" (Buyukgral, 2009, p. 24).

2. Key Issue for Performance Measurement

Studies have suggested steps for implementing performance metrics. They are: 1) Select Performance Metrics, 2) Establish Baseline Values for Each Performance Metric, 3) Set Target Values for Each Performance Metric, 4) Define an n-Dimensional Reward Scheme, and 5) Measure the Actual Effectiveness (Sols, Nowicki & Verma, 2008). Because of the number of available metrics, we must carefully consider which metrics we should use. Good measurement should 1) cover all aspects of the process being measured, 2) be appropriate for each situation, 3) be applied in a way that minimizes measurement error, and 4) be consistent with the management reward system (Mentzer & Konrad, 1991). After we select metrics, however, if they do not work well, we must replace them as necessary (Mentzer & Konrad, 1991). One of the biggest keys to succeeding in PBL is to select appropriate metrics that represent the system well, because metrics are the fundamental tools with which to evaluate PBL (Kim, Cohen, Netessine & Veeraraghavan, 2008; Landreth, Wilhelm & Corporon, 2005; Sols, Nowicki & Verma, 2008). Of course, the government should set goals for each metric, specifying the performance data that should be collected (Cohen, 2007).

3. Problems of Measurement

Measurement is very important for PBL management, but there are some pitfalls that include:

a. Difficulty of Determining Measurable Performance Standards

One study found that it was difficult to determine "measurable performance standards" (Ausink, Baldwin, Hunter & Shirley, 2002). For example, human behavior is difficult to measure, so we tend to skip these measurements though they are very important (Mentzer & Konrad, 1991).

b. Comparability of Measurement

Some metrics do not fit for all situations, so we often have to modify those metrics (Mentzer & Konrad, 1991). For example, if we want to evaluate the maintenance performance of an aircraft engine, we may use flight hours for the denominator of the

metric because the engine is working during flight, but if we want to evaluate the APU then flight hours may not be the appropriate denominator because the APU is not working during flight.

c. Measurement Error

Because it is difficult to find out what factors affect certain results, we sometimes collect inappropriate data (Mentzer & Konrad, 1991).

Table 1. Dimensions of Logistics Service Quality

Category 1	Category 2	Example
Effectiveness	Availability	Mission-capable rate Operational availability Partially mission capable supply Not mission capable supply Mission incapable awaiting parts System availability, sub-system availability Aircraft availability
	Readiness	Issue effectiveness Stockage effectiveness On time fill rates
	Reliability	Mean time between repairs (MTBR) Mean time between failure (MTBF) Break rates (BR) Mean Flight Hours Between Removals(MFHBR) Mean Flight Hours Between Unscheduled Removals(MFHBUR) Mission reliability Mean down time
	Customer feelings	Customer satisfaction Customer-Value added
Efficiency		Cost per Unit Usage Logistics footprint
Response time		Repair Turnaround Mean time to repair Logistics Response Time

D. RISK

Fourteen articles in the literature reviewed directly addressed risk. According to Spekman and Davis(2004), “risk is defined as the probability of variance in an expected outcome.” The literature reviewed concerning military PBL implementations addresses risk in the following way.

1. Risk in Supply Chain

Traditionally, risk permeates the supply chain, including such areas as inventory management, transportation, and financing. The best solution to allocating risk among the supply chain (or channel) members can be achieved if channel members are risk-neutral and the second-best solution involves a contract that combines a fixed payment, a cost-sharing incentive, and a performance incentive (Kim, Cohen & Netessine, 2007). Some PBL contracts may transfer supply chain risks from customers to suppliers (Cohen, 2007; Keating & Huff, 2005); therefore, suppliers demand a risk premium (Cohen, & Nines, 2008). The degree of risk transformation from customers to suppliers depends on the degree of authority or agency granted to the supplier in the PBL contract (Doerr, Lewis & Eaton, 2005). That means that if the customer gives more authority to the supplier, more risk will transfer from customer to supplier. However, the ultimate party responsible for any problems or failures in the supply chain is the government.

2. Contractor Technical Standards May Become Lower

Because of the heavy competition in cost, the government may accept lower standards of technology and accept higher and unrecognized risks (Tallant, Martin & Hedrick, 2008). One study found risk in not realizing the full capability and quality of third-party employees providing logistics services, due to inadequate managerial systems within the service-providing firm (Sink & Langley, 1997).

3. Ethics of Contractors

One study found that there are contractors and third parties who did not work in an appropriate manner or worked in a manner that was unethical (Chuter, 2009). In PBL contracts, suppliers get money by achieving performance such as availability; without quality metrics in a contract, suppliers may cut corners just to achieve performance, even if such corner-cutting could or does result in a significant mishap.

4. Skill Drain

As a form of outsourcing, PBL will necessarily transfer public sector work to the commercial sector, which means skilled manpower will drain from the public military to

the private civilian sector (Chuter, 2009). If PBL is applied to an entire weapon system, it may erode skills that currently military personnel have, because PBL will reduce their jobs, and therefore make it much more difficult to regain that organic capability should it be desired to do so in the future (GAO, 2008b; Reeve, 2001). Skills include not only technical skills but also management skills and once those skills are eroded, it is very costly to replace them (Chuter, 2009).

5. Risks Related to Cost

Any use of the weapon system beyond the contracted hours increases costs significantly and also requires negotiation of a modification to the existing contract; this is a risk that is borne by the government and contractor to varying degrees, depending upon how the contract is written. If the renegotiation takes time or is expensive, it may have an adverse impact on operations (Kirk & Depalma, 2005; Reeve, 2001). Second, "CLS contracts often guarantee a large amount of funding to the contractor in each fiscal year [and]this limits the flexibility of the government to reduce funding levels without violating the terms of the contract" (Boito, Cook & Graser, 2009). A third risk is associated with pricing the contract correctly, so analyzing the financial risk of a performance-based contract is a critical skill (Cohen & Nunes, 2008).

6. Capability to Assess PBL

If PBL is applied to an entire weapon system, the customer often lacks maintenance and logistics data to analyze PBL without cost (Boito, Cook & Graser, 2009). It is not unreasonable to assume that suppliers would charge significant sums of money to provide such data if they enjoyed a monopoly on such information. Additionally, if the customer cannot acquire those data, their BCA becomes unreliable (Kirk & DePalma, 2005). This presents a paradox, because the bigger the PBL contract becomes, the more difficulty the customer may have in conducting a BCA – meaning they may not be able to assess PBL appropriately or with any reasonable level of confidence.

7. Security of Information System

In PBL, data exchange and information sharing with contractors may be significant. When data sensitive information is shared between the government and an outside organization security problems are likely to occur (Spekman & Davis, 2004).

8. Contract Change

Some PBL contracts are fixed price contracts, and those prices are calculated by historical data. However, in PBL contracts for airplanes, if flight hours go up significantly because of deployment or some other reasons, suppliers will have huge deficits. As a result, the contractor may demand a change to the contract rather than face an adverse financial impact that might damage the firm or cause them to go out of business. (Kirk & DePalma, 2005)

9. Risk in Wartime

In wartime, contractors are not authorized to directly engage in armed battle and therefore require protection; this becomes a significant burden for combat squadrons, as they need additional force protection in order to provide safety to contractors (GAO, 2008b; Reeve, 2001). There are also considerable limitations on the timeframe for deploying contractors because they may not enter a particular area until the military commander assesses that area as safe (Reeve, 2001).

E. INFORMATION SYSTEM

Four articles directly addressed the information system for PBL. The information system is important in order for the customer and supplier to maintain the efficiency and competitiveness of PBL and to be able to evaluate it. The literature on military PBL implementations addresses the information system in the following way.

1. Information System to Improve PBL

Necessary data should be distributed to all PBL contractors, because currently, individual suppliers tend to keep most of data to themselves and subcontractors can only

access those contracts that are less attractive. However, if subcontractors could access those data, they would also be able to compete in some parts of PBL (Secretary of Defense, 2004).

2. Information System to Keep Ability

The information system is very convenient for tracking cost data. The customer should make efforts to collect standardized data to track the status of PBL efforts, so as to maintain the capability for continuous PBL evaluation (GAO, 2008; Inspector General, Department of Defense, 2004). Currently, GAO insists that customers should get benefit from IUID[15] and passive RFID[16] to grasp how materials are used and to have cost data (GAO, 2009).

F. WEAPON SYSTEM

Six articles directly addressed weapon system selection for PBL. Some studies insisted that converting all contracts to PBL is not optimal (Cohen, 2007). For example, if we want to make one-time, short-term contract, PBL may not fit. The contract may expire without any benefit for the customer because of the short term, or the supplier may not achieve a certain performance level because they have insufficient time to apply their skills. The literature of military PBL implementation addresses weapon system selection in the following way.

1. Four Levels of PBL Contracts

There are four levels for PBL: Level 1: components such as aircraft tires, Level 2: major subsystems such as aircraft engines, Level 3: platform availability such as F-117 Nighthawk, and Level 4: Mission, setting the stage for the future—achieving true pay for performance such as the Army shadow tactical unmanned aerial vehicle program. The government should consider what kind of work it will give to the contractors for each level (Vitasek, Cothran, Geary & Rutner, 2006).

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[15] IUID: IUID stands for Item Unique Identification. This system is used by DoD to identify individual parts or equipment.

[16] RFID: RFID stands for Radio Frequency Identification. This system can identify individual parts, boxes, or vehicles that have passive or active RFID tag.

2. Criteria of Theoretical Studies

Doerr, Lewis and Eaton (2005) suggest that PBL is good for those markets where, the system has external markets for services, the system has clear and objective outcomes to measure and contractors may be better equipped and able to support high technology or short lifecycle technology than the government. By using contractors, we can reduce the burden of maintaining modern, complicated equipment, because contractors can cover the whole life cycle of particular equipment and they can have strategic advantages in technology. This technical advantage helps PBL efficiency (Reeve, 2001).

On the other hand, PBL may not be efficient if we apply it to highly reliable systems (Kim, Cohen, Netessine & Veeraraghavan, 2008). Those systems may need no after-service during the entire contract term and, once broken, often have high systems costs. The result is that those contracts become very high risk/high return, which is not good for the customer or supplier.

3. Criteria of U.S. Military Experience

The U.S. Navy prefers to use PBL for expensive or delicate items, those for which readiness is a critical issue, and hard to manage candidates. It also says that "there must be a vendor who is willing to contract with the customer" and "the vendor must be affordable to the customer" (Kirk & DePalma, 2005). In the U.S. Air Force, newer aircraft tend to use PBL more than older aircraft (Boito, Cook & Graser, 2009).

G. ORGANIZATIONAL CAPABILITY

Sixteen articles directly addressed organizational capability. The literature on military PBL implementations addressed organizational capability in the following way.

1. Implementing PBL

At first, the customer should define the roles and responsibilities of contractors and government employees, which means defining when we should use contractors under what situation (GAO, 2008b). Once the customer decides to implement PBL, it should understand how suppliers do things, so that the customer can craft a solid contract with

suppliers (Ausink, Camm & Cannon, 2009). To do that, the customer needs to consider an in-depth evaluation of various agencies' use of performance-based contracting as it proceeds with this effort (GAO, 2002). Furthermore, the government needs to have a better understanding of how commercial firms have successfully implemented performance-based services acquisition (Ausink, Camm & Cannon, 2009). Managing suppliers is a critical capability that the organization must have in order for PBL to be effective (Cohen & Nunes, 2008).

PBL guidance and training requirements should be established so that all managers who take charge of PBL can follow these steps because, normally, those managers change frequently. If high turnover results in lost knowledge, PBL becomes inefficient (Inspector General, Department of Defense, 2004; Mendoza & Devlin, 2005).

Nowicki, Verma and Parry (2008) found that the government should consider the following when making contracts:

Clearly define the system for which support is sought;

Include definition of boundaries, primary external interfaces, definition of primary system elements such as hardware, software, human actions and activities, and;

Include details of support objectives, contract exclusions, system operational life, mission profiles and durations, measures of performance which includes frequency of measurement, continuity of key personnel and identify key focal points.

2. Evaluating PBL

The customer should have the ability to analyze current situations, such as manpower, organizational effectiveness and real cost (Tallant, Martin & Hedrick, 2008). To analyze current situations, the customer should obtain necessary PBL data (Boito, Cook & Graser, 2009). BCA guidance should be established, because it can give the customer the ability to evaluate PBL (Inspector General, Department of Defense, 2004). BCA guidance should clearly define "what should be included in a business case analysis and to establish specific criteria and methods for evaluating PBL support" and "when business case analyses should be updated during the weapon system life cycle" (GAO,

December 2008). The customer should implement formal oversight procedures as well, so that they can evaluate PBL according to a common standard (GAO, 2008a).

3. Maintaining Capability

Sometimes, the customer needs to reorganize to become an intelligent customer, because they neglect to maintain the ability to implement and evaluate PBL (Chuter, 2009). Normally, reorganization costs are extremely high; therefore, the customer should retain the choice of logistic service methodology so that they keep their ability to assess PBL (Boito, Cook & Graser, 2009). To do that, the customer should establish PBL training to keep its skills (Inspector General, Department of Defense, 2004; GAO, 2008a).

III. FINDINGS

A. COST

1. Cost Reduction

Though most organizations expect cost reductions as a result of implementing PBL, we should be aware that PBL does not always reduce costs, as many empirical studies have found. If the government takes no provision to ensure the lowering of costs during the drafting of a PBL contract, it is very difficult to reduce costs once the contract is in place. We found that, to have the benefit of cost reduction, we should do several things:

a. Cost Data Management

For cost reduction, cost data management is significant for government. The government should collect cost data not only of the PBL contract itself, but also for other actions such as maintenance, personnel, facilities, training, administration, documentation, technical data, and disposal. Cost data for contracts without PBL are really important, because if we do not have those cost data, we cannot find out whether we could reduce the cost or not. This idea is very straightforward but, in fact, many organizations (including JMSDF) often fail to have total cost data without PBL contracts for particular weapon systems. Once we could have useful cost data, we should track it continuously and regularly, because all cost components change rapidly and, if we fail to track cost data, risks due to the PBL contract will increase.

b. Government Should Have the Ability to Evaluate PBL Contracts

The government should have the ability to evaluate PBL contracts. The goal of any contractor is to maximize profits, so the government should not rely on cost data management by those contractors. The JMSDF may desire to outsource the evaluation of a potential PBL contract, or the business case analysis (BCA), to a third party, however, it is difficult for a third party to have accurate and sufficient cost data, because they do not have enough access to all documents and information at the

operational squadron level, and it will likely be difficult for a contractor to evaluate costs from inside the organization. In addition, some third parties may be untrustworthy or incompetent, so if the government has no ability to evaluate PBL contracts, it cannot evaluate accurately the reports submitted by those third parties and may subsequently enter into a poor, risky contract. Of course, if the government wants to have the ability to evaluate PBL contracts, it must bear some costs (e.g., training cost, manning cost and investment cost); generally, however, those costs should be smaller than the expected cost savings in the prospective PBL contract assuming the business case analysis contains proper, thorough and accurate cost calculations.

c. Government Should Maintain Marginal Administration and Technical Skills

It is very important for government to maintain marginal administration and technical skills, because it will lower future contract replacement or switching costs and the government should always reserve the option to cancel a contract. If we cut all applicable administration and technical skills, we can save money in the short-term, but once we lose those skills, the cost and time necessary to rebuild them may be immense. It is worth observing that the U.S. Army gave up the PBL contract for the Stryker because they could not effectively operate it under wartime conditions, due to increased force protection requirements for the contracted laborers on the battlefield; for every contractor there was a fixed and variable force protection cost and this drove up the logistical requirements as well as the personnel requirements. If we can keep replacement costs low, it will give strong incentives to contractors to reduce the cost. If they increase contract fees, contractors can expect that government will replace the PBL contract, because the government still has the ability to maintain a particular weapon system by itself.

Second, administration and technical skills are connected directly to the ability to evaluate PBL contracts in cost. If we have no administration and technical skills, we cannot collect or predict sufficient and appropriate cost data, because we do not have the knowledge to maintain a particular weapon system. From this point of view, we can also give incentive to contractors to reduce cost if we have marginal administration and technical skills, because we can evaluate cost more appropriately.

d. Apply Monetary Incentives

In theory, monetary incentives should work in a PBL contract to reduce costs because the cost reductions and improved performance the contractor delivers will offset the incentive payments (Sols, Nowicki & Verma, 2008). Empirical studies have found that, in some instances, monetary incentives improve performance and lower cost, but the exact amount by which performance was increased or costs were reduced is uncertain (Kirk & DePalma, 2005). The important conclusion is that the government should track the relationship between monetary incentives and performance, so that the government can have an appropriate amount of money for incentives.

2. Risk Premium

The government cannot calculate the appropriate price of a PBL contract just by having all the cost data of contractors, because the government has to take a risk premium into account. In PBL contracts, more risks will move from the government side to the contractor side as the contract level become higher, so it is natural for government to pay some money for contractors to accept some risks. The government should therefore consider the appropriate risk premium. Risk premium should not be considered simply as a profit of contractors, because contractors have to pay some costs (e.g., management cost, insurance cost and training cost) to take on the new risks.

3. Cost Over Life Cycle Time

The government should consider the costs, not of one PBL contract, but of all PBL contracts that will be made over the life cycle of a particular weapon system. Most PBL contracts are long-term; in fact, the JMSDF considers 5-year contracts. However, in most cases weapon system life cycles are longer than most PBL contracts or 5 years, so the government should have some plan to stretch PBL contracts of particular weapon systems over the projected life cycles of those systems. In these plans, the government should roughly estimate the increase of PBL contract price, and should have criteria to replace a PBL contract with an organic capability. The cost of transitioning from the PBL contract to an organic capability should also be recognized as part of the cost of the PBL contract at the outset.

4. PBL Contract Price and Replacement Cost

Figure 4 shows the cost of government and contractors, and the margin required to increase costs. To simplify this problem, we assume that in this case, contractors will do all of the administrative work, maintenance, and logistics for a particular weapon system. In Case 0, a PBL contract has not been implemented, so the government has 100 percent of the capabilities to include administration and technical skills; therefore, the estimated replacement cost should be zero. On the other hand, if the government wants PBL to reduce the cost, contractors have to offer lower PBL contract prices than the actual cost to the government; so, in Case 0, the estimated cost of contractors should be lower than the actual cost of government. After a PBL contract begins, because the government wants to reduce its total cost, it will remove all the capability for a particular weapon system as an overlapped capability and waste.

In Case 1, the government removed all the capabilities, driving up the estimated replacement cost due to this loss of capability. If it wanted to replace PBL, it would have to reconstruct facilities, buy or accumulate know-how, recruit soldiers and educate and train them; this replacement cost would likely become higher than the annual cost of government without a PBL contract over some period of time. Thus, it would become difficult for government to replace a PBL because the replacement cost is so high. On the other hand, contractors would have the margin to increase cost (or annual contract price) up to the replacement cost. Normally, contractors are very smart; they never overlook this margin. Thus, we can easily assume that contractors will increase the contract price in the second or third term of a PBL contract.

In Case 2, a PBL contract is implemented but government retains marginal capabilities. In this case, government has to use some money to maintain its marginal capabilities, but its cost is not prohibitive because it will reduce the number of its employees to just those required to maintain facilities and technical and managerial know-how. In fact, in fiscal year 2009, personnel cost accounts for 44.1 percent of the defense budget in Japan (Ministry of Defense, 2009). On the other hand, estimated replacement cost is also relatively smaller, because the government maintains its marginal capability and, if it wants to replace the PBL, it may train or recruit additional

personnel to perform the function.[17] In Case 2, the government maintains its very skilled personnel, so it is relatively easy to educate new personnel. In Case 2 of Figure 4, actual annual cost of government plus actual annual cost of contractors is greater than actual annual cost of government in Case 0. This assumption is reasonable because many empirical studies found no evidence of cost reduction by implementing PBL. If the government accepts this cost increase as a compensation for performance improvement, this situation is acceptable, but if the government is focused on cost reduction, then it will find this situation to be unacceptable. In that case, contractors will have some incentive to reduce costs so that the actual annual cost of government plus the actual annual cost of contractors becomes smaller than the actual annual cost of government in Case 0.

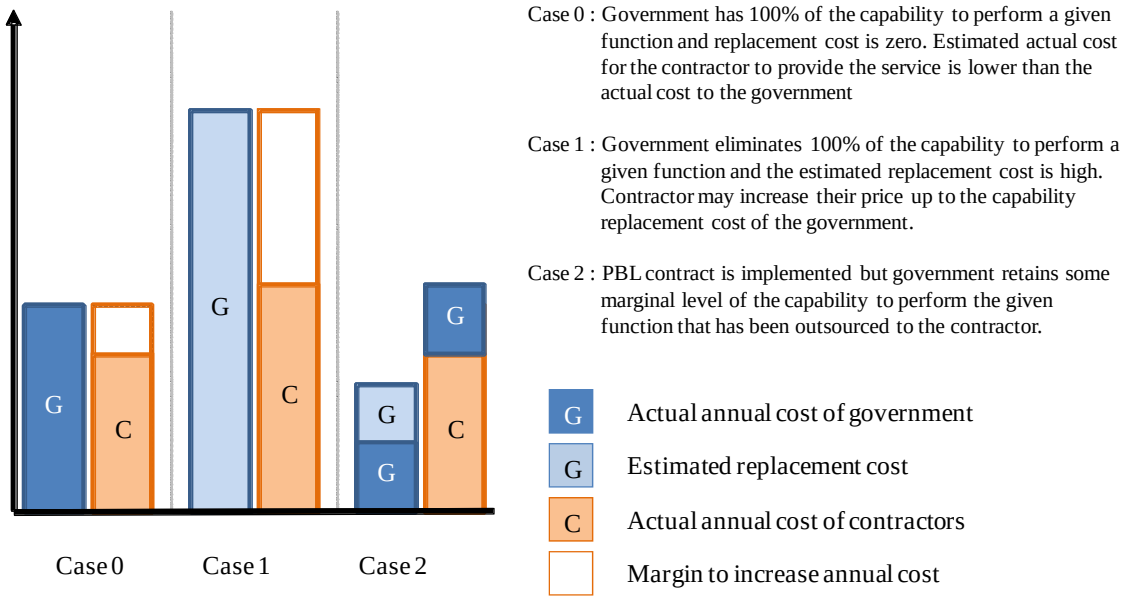

Figure 4. Cost of government and contractors, and margin to increase cost from annual view point

[17] Training and recruiting additional personnel to take over a function that has been outsourced may require significant time and money and therefore a transition plan or exit clause should be put in place in the contract to provide the government with enough time to build the capability necessary to perform the function effectively.

Figure 5 shows the relationship between organic capability and capability keeping cost or PBL replacement cost. Capability keeping cost includes facility maintenance cost and cost to maintain know-how as fixed costs, and personnel cost as a variable cost. Capability keeping cost will increase or decrease as organic capability increases or decreases. If the government removes all of its capability, capability-keeping cost becomes zero, but if the government maintains some capability, it needs to assume at least the fixed cost. We assume that the capability keeping cost will be linear because personnel cost is the only variable.

PBL replacement cost includes facility construction cost and buying or accumulating know-how cost as a setup cost and recruiting cost and retraining cost as variable costs. PBL replacement cost is a one-time cost. If government removes all of its capability, PBL replacement cost becomes very big, because government has to pay the setup cost. PBL replacement cost will be decreased as organic capability increases and when government has 100 percent of capability, PBL replacement cost becomes zero. We assume that PBL replacement cost goes down in an inverse proportion, because it is much easier for 1,000 soldiers than it is for 10 soldiers to retrain 100 soldiers.

In Figure 4, the total represents capability keeping cost plus PBL replacement cost. As the figure shows, at first total cost goes down as organic capability goes up, but at a certain point begins to rise as organic capability goes up, so there is a lowest point. If we add PBL replacement cost to longer-term capability keeping cost, this lowest point moves from the lower right to the upper left.

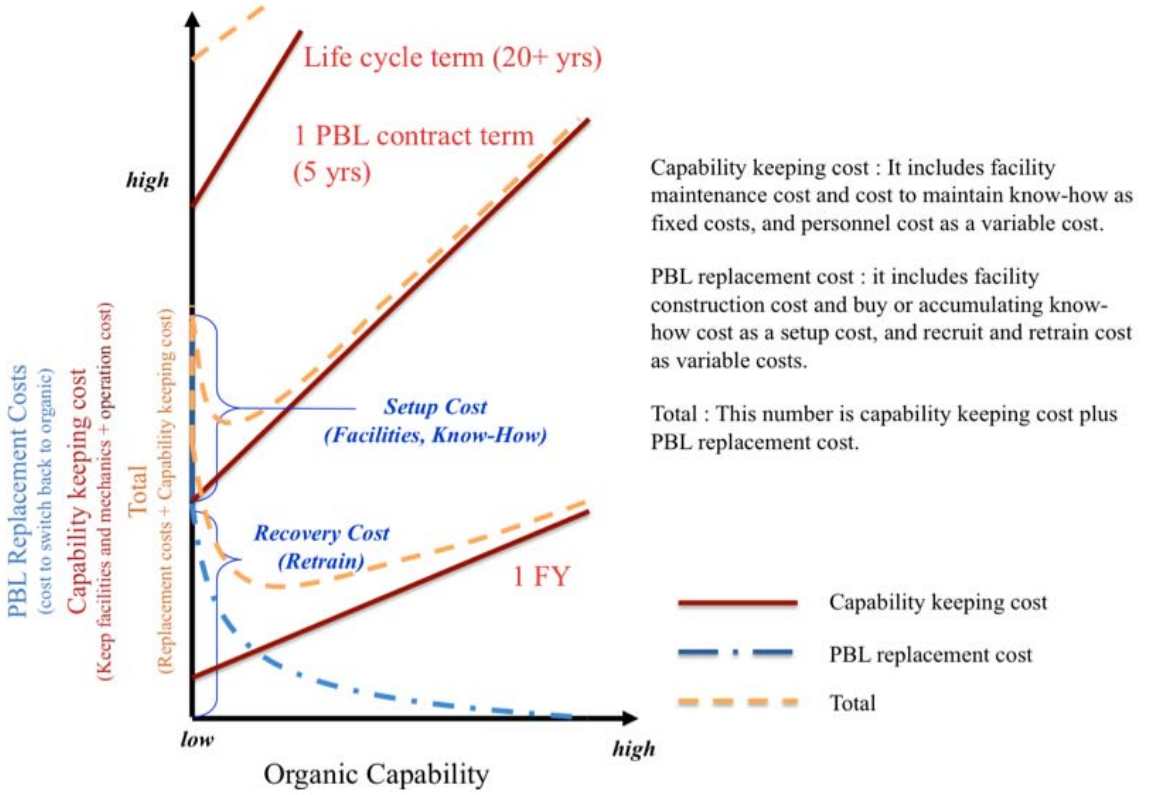

Figure 5. Relationship between organic capability and capability keeping cost or PBL replacement cost

Figure 6 combines Figure 4 and Figure 5. Case 2 is the optimal case, and the government has to seek this point. The government often considers cost from the viewpoint of a single fiscal year viewpoint, so the optimal point is relatively toward the right of the figure, but if the government can consider the longer term, it will move from right to left, and can save more capability keeping cost and total cost with PBL contract.

Though the cost is higher in Case 2 than in Case 0, this does not directly mean that total cost is higher in Case 2, because PBL often increases service level and can increase mission-capable rate, meaning that government needs fewer of each weapon system in total. Normally, government decides the number of weapon systems by considering the international situation then divides those numbers by mission-capable rate; from this, it will estimate the necessary number of weapon systems to possess. So, if mission-capable rate goes up, the necessary number of each weapon system will go down, and the acquisition cost or holding cost will go down.

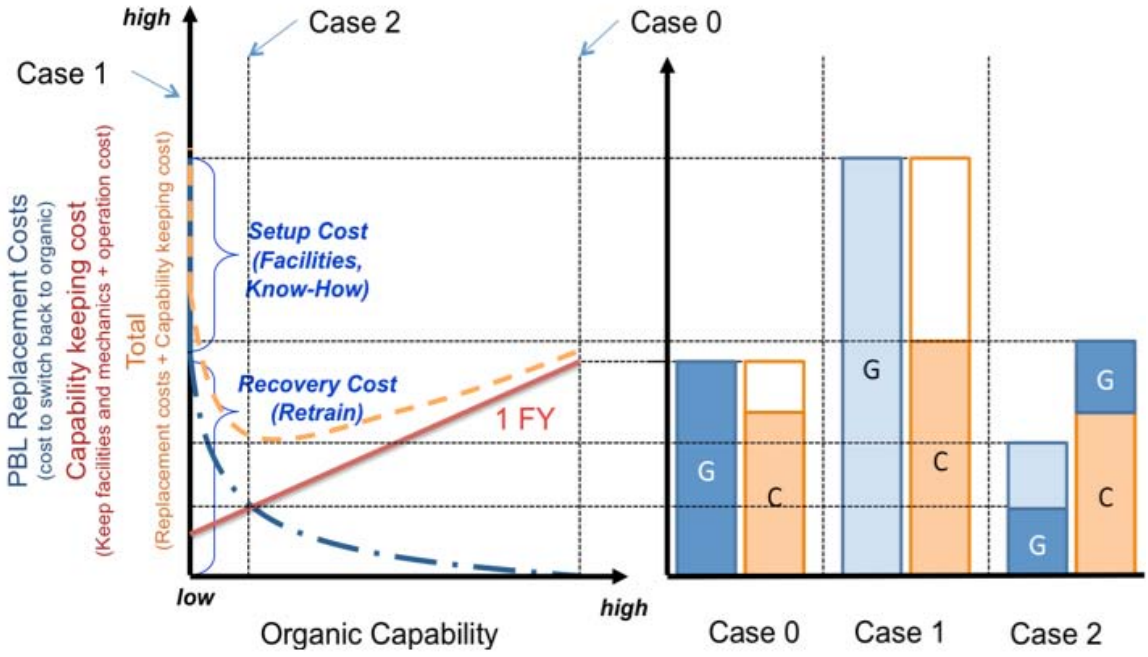

Figure 6. PBL price and replacement cost

B. PERFORMANCE

1. Performance Measurement Is Important for PBL Contract

Empirical studies found that a lot of PBL programs achieved high performance with a variety of weapon systems (Ahern, 2004; GAO, December 2008; Inspector General, Department of Defense, 2006). However, it is difficult to measure the performance because appropriate data is not collected. Additionally, it is even more difficult to measure the *cost for performance*—that is, measure the performance for a given resource investment. In fact, some studies could not find evidence that PBL increased performance (Inspector General, Department of Defense, 2004; Landreth, Wilhelm & Corporon, 2005). Performance evaluation is significant in PBL contracts because performance is the selling point of PBL. No one can evaluate contractors or the price of PBL contracts without evaluating performance appropriately, because we cannot bid some goods and services without grasping their capabilities or results. So, under PBL contracts, the government should evaluate performance continuously and regularly. The government is responsible for checking performance as it checks the number and quality of other goods that are delivered by contractors.

2. Appropriate Performance Data Are Needed

One of the most serious problems is that it is difficult to identify an appropriate measure of performance. If we cannot find a good measure, we cannot evaluate the performance of a PBL contract appropriately. After identifying an appropriate measure, we have to collect data constantly because performance of PBL contracts fluctuates every time and we may misunderstand the performance by the information from a snapshot of a particular time. Therefore, the government has to keep making efforts to correct appropriate performance data by good measurement. In this meaning, even if the government receives high performance from implementing PBL, that does not always mean that government time and effort for logistics will be reduced.

3. BCA is Necessary To Evaluate PBL

BCA provides the necessary methods and techniques to evaluate PBL contracts. BCA is not just a cost benefit analysis; it is composed of all analyses that are needed to evaluate PBL contracts. In other words, BCA is not one particular method, so government has to define BCA by itself and has to consider what should be included in BCA. BCA includes metrics selection and data collection, so government automatically has to continuously update BCA. The more frequently the government updates BCA, the more appropriately the government can evaluate PBL contracts and grasp performance of PBL.

The government tends to analyze PBL in the case of peacetime conditions, but it should also consider wartime operations in its BCA. Though JMSDF has not experienced severe war and most of their operations have been executed under peace situations or close to peace situations, JMSDF is designed to operate during war, and has to keep maintaining its weapon systems in such situations. Therefore, JMSDF has to collect or predict the data under combat conditions and put that information into its BCA.

C. PERFORMANCE MEASUREMENT

1. Significance of Selecting Appropriate Metrics

The most important thing to get correct with PBL is appropriate and effective metrics to measure performance. If we fail to select good metrics, the applicability and effectiveness of the BCA will be reduced or lost, because BCA is implemented by using the information provided by those metrics. For that reason, the government must strive toward better metrics. The government has to recognize the difficulty of measurement and measurement error, and has to reconfirm the measurement continuously and regularly.

2. Metrics Selection

It is difficult to find the best metrics for a particular PBL contract in one try; in other words, we can have much better metrics after several attempts, so metrics should be evaluated and updated periodically. If a particular metric is not effective then it should be changed, and efforts made to improve performance metrics so that we can evaluate PBL more appropriately. On the other hand, changing performance metrics has implications for writing contracts and contract durations because it may be necessary to change the metrics in a given contract. For this reason, there needs to be flexibility in the contract to change the metric but not so much flexibility as to open up all parts of the contract, which would effectively mean a renegotiation that increases costs. The government also has to make efforts to reduce the number of trials needed to determine satisfactory metrics; this will reduce the opportunities to change contracts and increase costs. To do that, it is better for the government to set standardized steps to choosing metrics.

D. RISK

1. Risk Sharing

One of the features of PBL is risk sharing. The contractor will likely charge for the cost of taking on risk for the government and the premium for that risk will be reflected in the contract price. So, PBL is not such a simple program—there are complexities. We should not regard the risk premium as a simple profit for contractors,

because it is the value of risk sharing. The government can reduce risks associated with inventory, transportation or contingency expenditure caused by particular trouble, and contractors sell these risk reductions like insurance companies.

2. Chain of Command

There is also risk associated with not having the particular function or service directly under the control of the government and therefore subject to the chain of command. For example, a dispute must be resolved through civil (or administrative) courts as opposed to the direct chain of command (or the Uniform Code of Military Justice, in the case of the U.S.).

3. Organization Skills

Administration and technical skill will more or less drain from the government, because contractors will assume some duties that were conducted by government employees. If the government loses entire skill sets, replacement cost becomes very high and PBL evaluation capability becomes very low. Replacement cost growth means that the incentives for the government to replace PBL contracts will decrease and it will be difficult for the government to give up PBL; this is because, if replacement cost becomes high, it is more difficult to persuade finance sections to replace PBL. If the government's PBL evaluation capability becomes low, the government is more likely to make inappropriate and disadvantageous contracts, and once the government makes unfavorable contracts, it cannot notice that these contracts are not appropriate. Then government will have no option to continuing inappropriate PBL contracts.

The government should not forget that the government itself is the competitor of contractors because it has same skills (before PBL contracts) as competitors have for particular weapon systems. If the government loses its skills, the strongest competitor will be dismissed, and we can easily predict that the PBL contract price goes up.

4. Data Sharing

If PBL contracts expand to cover almost all weapon systems, it becomes harder for government to have maintenance and logistics data, either because it does not need to

gather data itself or because contractors restrict direct access to the pertinent cost or performance data and, generally, charge high rates when they do provide access. If the PBL contract expands, the government should analyze it more strictly, because unsuitable parts of such a big contract could lead to huge waste. It is something of a paradox because the bigger the PBL contract becomes, the more difficulties the customer encounters in BCA, leading to inaccurate assessment of PBL. So the government should mention data treatment or data ownership in the PBL contracts in order to maintain access to data that are needed to implement appropriate BCA.

There is another problem in data sharing. Security issues may arise in PBL contracts, due to governmental need to share a lot of data with contractors. For example, if contractors work in the hangars at military air bases, the government may need to take certain measures to guard secrets.

5. Wartime Operations

Generally, during war, a PBL contract is not suitable because contractors cannot fight and they need enough protection by military people, and contractors cannot work in the place where safety is not guaranteed. For this reason, contractors cannot work on ships.

E. INFORMATION SYSTEMS

1. Information Systems to Improve PBL

We have to shrink the turnaround time of information; for example, if we use some parts or some assemblies in our hangar then that information should be sent immediately to the contractor so that they may reduce the inventory or turnaround time. The inventory or turnaround time reduction in the contractors' section directory connects to the price of the PBL contract, so it is significant not only for contractors but also for the government to have immediate information exchange. Information systems must be integrated with the work on the shop floor without delay. For example, if maintenance work is performed on the shop floor but the usage of spare parts or maintenance man-hours is not entered into the system until months later then it is impossible to accurately

plan and forecast for resources such as parts and labor, and turnaround time goes up. This, in turn, can cause safety stock and pipeline stock increase. To avoid this, the government should improve information systems for PBL that connect government and contractors. RFID and IUID may be very beneficial as mechanisms for transmitting information about usage of parts or the status of a weapon system or component.

2. Information Systems to Evaluate PBL

An information system is also very important to collect necessary data to evaluate PBL contracts, because the government cannot evaluate PBL by its own information alone. The government should have some cost and performance data from the contractor's section so that government can implement appropriate BCA. When the government collects data, cost and performance data should be collected by standardized format so that the government can track those data. This effort will help the government to evaluate PBL appropriately and frequently.

F. WEAPON SYSTEM

1. Weapon System Selection

PBL is not right for every situation, so the government should carefully consider for which elements they should implement PBL contracts. To select weapon systems for PBL, the government should first settle upon the criteria by which they are operating.

a. Suitable Weapon Systems for PBL

High-technology weapon systems or components are good for PBL contracts, because government people will be released from the burden to understand and struggle with such a complicated system in some extent.

b. Unsuitable Weapon Systems for PBL

There are some unsuitable weapon systems for PBL. For example, if a particular weapon system is very special (i.e., particularly complex or expensive to produce and those numbers are very small), such a weapon system is not good for a PBL contract, because the contractor feels difficulty in managing spare parts flexibly or

reusing the administration skills for such a system. A PBL contract is not good for highly reliable, limited-run weapon systems either, because normally, such weapon systems are very expensive with very high benefit and risk. The government should not take such a gamble.

2. PBL Contract Level

The higher the PBL contract level becomes, the more complicated the PBL contract becomes, which can cause the government more difficulties. The JMSDF will not have trouble understanding the mechanism of PBL in its pilot model, because that PBL contract is at the component level, which is not complicated. However, JMSDF is considering introducing PBL to the higher-level contracts; if that happens, the incentives and risks will become more complicated and JMSDF will feel the increased difficulties. For this reason, JMSDF should not raise contract levels until it has given careful thought to the complicated issues at each level of PBL contracts.

G. ORGANIZATIONAL CAPABILITY (FUNCTIONAL CAPACITY AND COMMAND AND CONTROL)

1. Government Should Have Policy for PBL

Government should have a policy for PBL. This policy should include 1) the main reason to use PBL contracts (e.g., cost reduction, performance increase or risk sharing), 2) the roles and responsibility of government and contractors, 3) replacement criteria, 4) maximum PBL contract levels for practical-use weapon systems and training weapon systems, and so on. If the government does not have a concrete policy for PBL, PBL contracts are more likely to be unsuitable. Contractors always have a concrete policy—maximize profit—so the government may be at a disadvantage if it has no policy for PBL. The government should review its policy based upon national security issues, budgetary concerns, the latest technologies, business trends, suppliers' behaviors and their skills or knowledge about PBL, and must apply the policy to the PBL contracts.

2. Government Should Establish Guidance and Training for PBL and BCA

PBL contracts are complex and difficult to understand for military people, whose standard tours of duty (typically 2–3 years) makes it hard for them to study enough about PBL before moving on to other jobs. In fact, the officer who is responsible for PBL contract in JMSDF has not been able to conduct his own study about PBL by himself. In addition, PBL is a very flexible contract approach, so if the officer who takes charge of PBL contracts changes, the policy for PBL may be changed entirely. To combat this, the government should have a concrete and stable policy for PBL to maintain appropriate PBL contracts. It should establish PBL guidance and training so as to maintain the ability to manage and evaluate PBL contracts even if the people who are responsible for PBL contracts would be changed frequently. The government also should establish the basic framework of conditions and terms that should be defined in the contract, to ensure that its policy for PBL is spelled out in the contract language.

For the same reasons, the government should establish BCA guidance that supports the officers who take charge of PBL contracts, in order to consider what should be included in the BCA and give them some incentive to update the BCA frequently. If the government outsources the BCA, it should have BCA guidance, so that BCA contractors can work appropriately. The U.S. government has issued many PBL guidance documents. Table 2 provides examples of PBL guidance documents for the person implementing PBL.

Table 2. Examples of PBL guidance documents for the person implementing PBL

Service	PBL guidance documents *for the person implementing PBL*
DoD	Department of Defense. (2005, March). *Performance based logistics: A program manager's product support guide.* Defense Contract Management Agency. (n.d.). *Performance based logistics (PBL) support guidebook.* Department of Defense. (2003, November). *Business case development guide.*
Army	Department of the Army. (2005, August 18). *Performance-based logistics (PBL) business case analysis (BCA) policy.* Deputy Assistant Secretary of the Army. (2004, May 4). *U.S. Army implementation guide performance-based logistics (PBL).*
Navy	Department of the Navy. (2003, January 27). *Department of the Navy (DoN) performance based logistics (PBL) guidance document.* Naval Inventory Control Point. (n.d.). Maritime PBL deskguide. Department of the Navy. (2007, November 6). *Department of the Navy guide for developing performance based logistics business case analyses (P07-006).* Department of the Navy. (2003, June). Operational availability handbook.
Air Force	Secretary of the Air Force. (2004, November 10). *Integrated product support planning and assessment.*
Marin Corps	Department of the Navy. (n.d.). *United States Marine Corps performance based logistics (PBL) guidebook.*

3. Government Should Keep Marginal Administration and Technical Skills

The government can make its logistics and maintenance sections smaller, but it should keep the marginal administration and technical skills so that it will not lose the ability to implement and evaluate PBL contracts. This also helps cost savings, because contractors feel that government can replace a PBL contract relatively easily if it maintains its relevant skilled personnel.

IV. CONCLUSIONS

A. PBL IS NOT A VERY STRAIGHTFORWARD SYSTEM

The U.S. Department of Defense has stated that PBL is the preferred sustainment model for weapon systems. How long the U.S. will continue to pursue PBL as a sustainment model is unknown especially given the mixed results of cost and performance found in the literature. The JMSDF is shifting from traditional contracts to PBL contracts it should not forget that PBL is a complicated contract system because of the many variables involved compared to traditional contracts. PBL contracts include not only visible goods or service, but also invisible services such as risk sharing; those invisible services make it more difficult to grasp PBL contracts. Therefore, many studies could not find cost reduction or a relationship between monetary incentives and performance. Though it is difficult to understand and analyze PBL, the government cannot maintain optimal PBL contracts without tracking appropriate data and analysis.

B. SEVEN IMPORTANT PREPARATIONS OR CONSIDERATIONS

The government should consider seven important issues: cost, performance, performance metrics, risk, information systems, weapon systems and organizational capability.

1. Cost

For the cost reduction, cost data management is vital for government. The government should collect appropriate cost data and track them continuously and regularly. It is better for the government to have the ability to evaluate PBL contracts by itself, because contractors or third party evaluators may not evaluate PBL appropriately. And the government should maintain marginal administration and technical skills to keep the PBL contract price lower and to maintain the ability to evaluate PBL contracts. On the other hand, monetary incentives are useful to reduce cost, but the government should track cost data and determine the relationship between monetary incentives and performance so that it pays reasonable monetary incentives.

The government has to understand risk premium, which is not to be considered as simple profit for contractors. It is also important for the government to consider matters from the viewpoint of the entire life cycle, because PBL contracts' terms are normally shorter than life cycles of most weapon systems, and it is important for the government to have some plan, not only for single PBL contracts, but also for all the PBL contracts that will be made over the life cycle of a particular weapon system.

2. Performance

Performance measurement is important for PBL contracts because performance is deliverable under PBL contracts. However, it is difficult to measure performance, so government should collect appropriate performance data. BCA is necessary to evaluate PBL, but BCA does not require a particular method, so government has to consider what considerations it will include in the BCA. Also, the government should implement BCA not only for peacetime but also for wartime scenarios.

3. Performance Metrics

The most important thing to get correct with PBL is appropriate and effective metrics to measure performance; those metrics should be reviewed regularly. If the government decides to change some metrics, it may have to change the PBL contract, and sometimes that costs money. Therefore, the government should make efforts to reduce the number of changes; standardized steps to choose metrics may help government to reduce that number.

4. Risk

One of the features of PBL is risk sharing, so the government will be released from inventory risk or transportation risk to a certain extent. On the other hand, there are some risks caused by PBL such as dispute solutions between government and contractors, organizational skills drain, data sharing and wartime operations. The government should recognize those risks so that it will not fail in PBL.

5. Information Systems

Information systems are significant for PBL because they help to reduce turnaround time, which in turn helps both contractors and the government to reduce costs. Information systems also help the government to evaluate PBL.

6. Weapon Systems

PBL is not a solution for all occasions, so the government should consider for which elements it should implement PBL contracts. Generally, high-technology weapon systems or components are good candidates for PBL, but low-production special weapon systems or highly reliable weapon systems are not suitable for PBL. The government also should consider PBL contract levels and understand the differences between each level.

7. Organization Capability

The government should have a concrete policy for PBL, because if the government does not have a policy, it may make an inappropriate PBL contract. To reflect those policies in all PBL contracts, the government should establish guidance and training for PBL and BCA. The U.S. government has issued extensive guidance about PBL and BCA. It is also important for the government to keep marginal administration and technical skills to keep the contract price lower and keep its abilities to evaluate PBL.

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V. RECOMMENDATIONS

PBL is just starting in JMSDF, so there is much work to do, but the human resources remain limited. The JMSDF should solve problems and increase ability incrementally. Thus, we classified our recommendations as short-term recommendations for up to 5 years into the future, intermediate recommendations for 5 years to 10 years into the future, and long-term recommendations stretching over 10 years into the future.

A. SHORT-TERM RECOMMENDATIONS

1. JMSDF Should Understand the Intricacy of PBL

The most significant issue for JMSDF is to understand clearly about complicated PBL mechanisms, which are gradually more complicated as the contract level goes up. Cost restraint, performance improvement and risk sharing are interrelated, so JMSDF should understand PBL in a general sense. In high contract levels, JMSDF may not be able to see evidence of direct cost reduction, but there are some possibilities to identify cost reduction if JMSDF understands the mechanisms of PBL and can consider it from a wider viewpoint. By understanding PBL, JMSDF will be able to exploit PBL more efficiently, and it will be easier to convince taxpayers of its benefits.

2. JMSDF Should Have Policy for PBL

On the basis of deep insight about PBL, JMSDF should have develop a concrete policy for its use. Though PBL has a variety of expected effects such as cost reduction, performance increase, risk sharing and so on, JMSDF should prioritize these effects so as not to deviate form the purpose of PBL.

3. JMSDF Should Have Long-Term Plan for PBL

After making a concrete PBL policy, JMSDF should make a long-term plan, because PBL requires significant efforts to begin, and even greater efforts to replace once implemented. First, JMSDF should begin studying PBL without contractors or third parties. Even if imperfect, such work should still contribute significantly to implementing PBL, using third parties and negotiating with contractors. Second, though it is natural to

focus on the rewards of a new program, JMSDF should recognize the risks caused by PBL such as chain of command risks, organization skill drain, data sharing risks, etc. To avoid or mitigate those risks, JMSDF should evaluate PBL over life cycle time, and should generate and maintain at least marginal administration and technical skills.

B. MIDDLE-TERM RECOMMENDATIONS

1. JMSDF Should Establish Criteria to Decide Whether PBL Should Be Used or Not

JMSDF is planning to spread PBL contracts to entire weapon systems, but they should recognize that PBL is not a perfect fit for all systems. Some weapon systems fit PBL very well; on the other hand, some weapon systems do not fit PBL. So it is important for JMSDF to define precise criteria to decide whether PBL should be used for a particular weapon system.

2. JMSDF Should Consider Exploiting Monetary Incentives

Incentives are argued to make cost reduction and performance improvement go together, though they are incompatible under traditional contract approaches. It is difficult for JMSDF to exploit monetary incentives because of the national law constraints, but to improve PBL, JMSDF should consider ways to exploit monetary incentives.

3. JMSDF Should Have the Ability to Evaluate PBL by Itself

As we mentioned, JMSDF should have ability to evaluate PBL by itself. To do so, JMSDF should increase the number of personnel who are responsible for PBL, because as the number of PBL contracts increases, it becomes impossible to evaluate all these contracts with only a few personnel. To increase the number of personnel proficient in PBL, JMSDF should make PBL and BCA guidance and training programs; then, the personnel who are responsible for PBL will have similar significant knowledge about PBL and will completely understand the JMSDF policy for PBL. For PBL contracts for

aviation, not only MMC but also 3rd Maritime Service School should study and develop PBL and BCA guidance and training programs, and embed PBL training in officers' education in 3rd Maritime Service School.

4. JMSDF Should Conduct Appropriate BCA Before and After PBL Implementation

BCA should be conducted after a PBL contract starts, but BCA also should be appropriately conducted before a PBL contract starts so that JMSDF can grasp the current situation under traditional contracts. This initial BCA will help JMSDF to consider PBL replacement criteria.

5. JMSDF Should Improve Information Systems for PBL

JMSDF should improve information systems for PBL to evaluate and improve PBL contracts. They should correct appropriate cost and performance data for efficient PBL contracts, and they should specify the data treatment in the contract papers.

6. JMSDF Should Send Officers to the United States Naval Postgraduate School

Though the officers of JMSDF must be able to understand PBL and conduct PBL appropriately by themselves, it is important for the officers to understand a variety of economic concepts, such as supply chain management, microeconomics and organization behavior to completely understand PBL. There are just a few universities that offer MBA courses in Japan, and the National Defense Academy does not have an MBA course despite offering a doctoral program. So, it would be beneficial for JMSDF to send officers to the United States Naval Postgraduate School to make them study the economy and business principles from both the general and military viewpoints.

C. LONG-TERM RECOMMENDATIONS

1. National Defense Academy Should Have a Business and Administration School

Though we can study in many American or Japanese universities or colleges about the economy generally, Japan has a very unique economic culture and JMSDF also has a special culture, so to create a Japanese-specific understanding of PBL, the National Defense Academy should have a Business and Administration School, which is good not only for PBL but also for the entire logistics needs of the Japanese military services. That school also can reinforce human resources for logistics in the Japan Self Defense Force.

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